



Department of Transportation  
**Federal Aviation Administration**  
Aircraft Certification Service  
Washington, D.C.

<b>TSO-C16b</b>
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Effective  
Date: 1/27/17

# Technical Standard Order

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**Subject: ELECTRICALLY HEATED PITOT AND PITOT-STATIC TUBES**

1. **PURPOSE.** This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your electrically heated pitot and pitot-static tubes must first meet for approval and identification with the applicable TSO marking.

2. **APPLICABILITY.** This TSO affects new applications submitted after its effective date.

a. TSO-C16a will also remain effective until June 27, 2018. After this date, we will no longer accept applications for TSO-C16a.

b. Electrically heated pitot and pitot-static tubes approved under a previous TSOA or LODA may still be manufactured under the provisions of its original approval.

3. **REQUIREMENTS.** New models of electrically heated pitot and pitot-static tubes identified and manufactured on or after the effective date of this TSO must meet the qualification and documentation requirements in; SAE International (SAE) Aerospace Standard AS8006A, *Minimum Performance Standard for Pitot and Pitot Static Probes*, Revised August 2015 as modified in Appendix 1 of this TSO, and SAE AS5562, *Ice and Rain Minimum Qualification Standards for Pitot and Pitot-Static Probes*, Issued August 2015 as modified in Appendix 2 of this TSO.

a. **Functionality.** This TSO's standards apply to equipment intended to function as pitot and pitot-static tubes that are electrically heated by aircraft power and intended to provide pitot and/or static pressure. The electric heater function is defined as starting with the aircraft interface (connector). The pneumatic pressure function is defined as starting with the pressure transducer interface if it is integrated with the probe or starting with the aircraft interface if the pressure transducer is separated from the probe.

**b. Failure Condition Classifications.** There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classification for which the equipment is designed.

**c. Functional Qualification.** Demonstrate the required functional performance under the test conditions specified in SAE International (SAE) Aerospace Standard AS8006A, *Minimum Performance Standard for Pitot and Pitot Static Probes*, Revised August 2015 as modified in Appendix 1 of this TSO, and SAE AS5562, *Ice and Rain Minimum Qualification Standards for Pitot and Pitot-Static Probes*, Issued August 2015 as modified in Appendix 2 of this TSO.

**d. Environmental Qualification.** Demonstrate the required performance under the test environments test conditions specified in SAE International (SAE) Aerospace Standard AS8006A, *Minimum Performance Standard for Pitot and Pitot Static Probes*, Revised August 2015 as modified in Appendix 1 of this TSO, and SAE AS5562, *Ice and Rain Minimum Qualification Standards for Pitot and Pitot-Static Probes*, Issued August 2015 as modified in Appendix 2 of this TSO.

**e. Deviations.** We have provisions for using alternate or equivalent means of compliance to the criteria of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under the provision of 14 CFR § 21.618.

**f. Software Qualification.** If the article, as defined in paragraph 3.a of this TSO, includes software, develop the software according to RTCA, Inc. Document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph 3.b of this TSO. You may also develop the software according to RTCA, Inc. Document RTCA/DO-178B, dated December 1, 1992, if you follow the guidance in AC 20-115C, *Airborne Software Assurance*, dated July 19, 2013.

**g. Electronic Hardware Qualification.** If the article, as defined in paragraph 3.a of this TSO, includes complex custom airborne electronic hardware, develop the component according to RTCA, Inc. Document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, dated April 19, 2000, to at least the design assurance level consistent with the failure condition classification defined in paragraph 3.b of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.

**4. MARKING.**

**a.** Mark at least one major component permanently and legibly with:

- (1) All the information in 14 CFR § 45.15(b); and,
- (2) The TYPE and CLASS designation in accordance with SAE AS5562 paragraph 1; and,
- (3) All the information in SAE AS8006A paragraphs 3.5.4 and 3.6.

**b.** If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

**5. APPLICATION DATA REQUIREMENTS.** You must give the FAA aircraft certification office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR § 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.g**) through their civil aviation authority.

**a.** A manual(s) containing the following:

- (1) Operating instructions and article limitations sufficient to describe the equipment's operational capability.
- (2) Describe in detail any deviations.
- (3) Installation procedures and limitations sufficient to ensure that the electrically heated pitot and pitot-static tube, when installed according to the installation or operational procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must include a note with the following statement:

“This article meets the minimum performance and quality control standards required by a technical standard order (TSO). Installation of this article requires separate approval.”

(4) For each unique configuration of software and airborne electronic hardware reference the following:

- (a) Software part number including revision and design assurance level;
- (b) Airborne electronic part number including revision and design assurance level;

(c) Functional description.

(5) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the electrically heated pitot and pitot-static tube.

(6) List of replaceable components, by part number, that make up the electrically heated pitot and pitot-static tube. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the electrically heated pitot and pitot-static tube continues to meet the TSO approved design. Include inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph 4. of this TSO.

f. Identify functionality or performance contained in the article not evaluated under paragraph 3. of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization but are not approved. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

(1) Description of the non-TSO function(s), such as performance specifications, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph 3.

(2) Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance specification(s) described in paragraph 5.f.(1).

(3) Instructions for continued performance applicable to the non-TSO function(s) described in paragraph 5.f.(1).

(4) Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph 5.f.(1).

(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

(6) Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph 5.f.(1).

g. The quality system description required by 14 CFR § 21.608, including functional test specifications. The quality system should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

h. Material and process specifications list.

i. List of all drawings and processes (including revision level) that define the article's design.

j. Manufacturer's TSO qualification report(s) showing results of testing accomplished according to paragraph 3. of this TSO.

k. A compliance matrix identifying all of the requirements in this TSO and identification of the technical data on file at the manufacturer which substantiates compliance with each TSO requirement.

**6. MANUFACTURER DATA REQUIREMENTS.** Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

a. Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

b. Article calibration procedures.

c. Schematic drawings.

d. Wiring diagrams.

e. Material and process specifications.

f. The results of the environmental qualification tests conducted according to paragraph 3. of this TSO.

g. If the article includes software, the appropriate documentation defined in RTCA/DO-178B or RTCA/DO-178C specified in paragraph 3.e of this TSO, including all data supporting the applicable objectives in RTCA/DO-178B Annex A, *Process Objectives and Outputs by Software Level*.

h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-1. For simple custom airborne electronic hardware, the following data: test cases or procedures, test results, test

coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.

i. If the article contains non-TSO function(s), you must also make available items **6.a** through **6.h** as they pertain to the non-TSO function(s).

## **7. FURNISHED DATA REQUIREMENTS**

a. If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5.a** and **5.b** of this TSO. Add any other data needed for the proper installation (i.e., data identified in subsection 4.1, 4.5, and 4.10 of SAE AS5562), certification, use, or for continued compliance with the TSO, of the electrically heated pitot and pitot-static tubes.

b. If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.f.(1)** through **5.f.(4)**.

## **8. HOW TO GET REFERENCED DOCUMENTS.**

a. Order RTCA documents from RTCA Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at [www.rtca.org](http://www.rtca.org).

b. Order SAE documents from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Telephone (724) 776-4970, fax (724) 776-0790. You can also order copies online at [www.sae.org](http://www.sae.org).

c. Order copies of 14 CFR parts 21 and 45 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also order copies online at [www.gpo.gov](http://www.gpo.gov).

d. You can find a current list of technical standard orders and advisory circulars on the FAA Internet website Regulatory and Guidance Library at <http://rgl.faa.gov/>. You will also find the TSO Index of Articles at the same site.



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## Appendix A

The following Appendix modifies the text in SAE International's (SAE) Aerospace Standard (AS) 8006A, *Minimum Performance Standard for Pitot and Pitot Static Probes*, Revised August 2015. Compliance to the modified text is mandatory in order to comply with the requirements of this TSO.

<b><i>When Reading AS8006A...</i></b>	<b><i>Do the following:</i></b>
Section 1	Apply all subsections
Section 2	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 1, Replace subsection 2.1, with the following text:</p> <p>2.1 Applicable Documents</p> <p>The following publications form a part of this document to the extent specified herein. The applicable issue of <i>cited</i> publications shall be the issue in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific <i>deviation or exemption</i> has been obtained.</p> <hr/> <p>Page 2, subsection 2.2.7, Disregard the definition of MUST– it is not used in this document</p>
Section 3	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 3, replace subsection 3.4.2 with the following text:</p> <p>3.4.2 Particle Separation Features</p> <p>The probe shall be designed with baffling or a pitot settling chamber, or both, to minimize the entry of liquid or solid particles into the tubing connecting the probe to the aircraft instruments. There shall be at least one drain hole to discharge or scavenge entrained liquid, such as rain or melted ice water. The probe design <i>shall</i> consider the effects of ingested solid particles such as ice, sand and dust.</p> <hr/> <p>Page 3, replace subsection 3.4.3 with the following text:</p> <p>3.4.3 Misinstallation</p> <p>The probe <i>shall</i> incorporate design features to minimize the potential for misinstallation on the aircraft. For example, in the case where the probe contains multiple pneumatic or electrical connections these features may</p>

	<p>include the incorporation of different pneumatic fitting sizes or types, or different electrical connector keying.</p> <hr/> <p>Page 3, replace subsection 3.4.4 with the following text:</p> <p>3.4.4 Interchangeability</p> <p><i>Design changes to the pitot or pitot static tube shall be made in accordance with 14CFR 21.619. Interchangeability at the product (i.e. aircraft) level is determined with respect to the airworthiness regulations (e.g. 14CFR part 23, 14CFR part 25, etc.) by the installer in accordance with 14CFR Parts 21 and 43.</i></p> <hr/> <p>Page 4, replace subsection 3.4.11 with the following text:</p> <p>3.4.11 Finishes</p> <p>Protective coatings and finishes utilized in the construction of the probe <i>shall</i> not crack, chip, or scale to the extent that the probe no longer meets the aerodynamic accuracy requirements when exposed to the qualification test requirements of this <i>TSO</i>.</p>
Section 4	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 7, replace the second paragraph in subsection 4.6 with the following text:</p> <p>Other means can be used to demonstrate compliance with this requirement provided there is evidence they are equivalent or better than the specified test. <i>Other means to demonstrate compliance are considered a deviation subject to 14CFR 21.618.</i></p>
Section 5	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 12, replace subsection 5.26 with the following text:</p> <p>5.26 Fire, Flammability</p> <p>Non-metallic probes shall be tested for compliance to fire and flammability tests in accordance with EUROCAE ED-14G / RTCA DO-160G Section 26, Category C. <i>If ignition were to occur</i> inside or outside of the equipment, the probe shall not propagate the flame. Tests are not required for metallic probes.</p>
Section 6	Apply all subsections
Section 7	Disregard



## Appendix B

The following Appendix modifies the text in SAE International's Aerospace Standard (AS)5562, *Ice and Rain Minimum Qualification Standards for Pitot and Pitot-static Probes*, dated August 2015. Compliance to the modified text is mandatory in order to comply with the requirements of this TSO.

<b><i>When Reading AS5562...</i></b>	<b><i>Do the following:</i></b>
Section 1	<p>Apply all unless disregarded or modified below:</p> <hr/> <p>Page 1, Replace the second paragraph with the following:</p> <p>The user of this standard must evaluate the aircraft level installation requirements for the probe against the class definition criteria to ensure adequate coverage for the application. It may be necessary to step up in class or modify the test conditions in order to meet the applicable installation requirements. <i>Modifications to the test conditions may only be applied if an equivalent level of safety is documented, justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p> <hr/> <p>Replace the first "NOTE" with the following:</p> <p>NOTE: Class 2 is divided into two subgroups identified as either Class 2a or Class 2b. Class 2a probe applications typically include aircraft that operate within the mid to lower end of the Class 2 altitude range and that only use probe output to display basic airspeed and/or altitude. As such, Class 2a probes do not have to test ice crystals at an altitude-capable icing tunnel. Class 2b applications are for probe installations intended to serve a critical function and <b><i>shall</i></b> be tested at an altitude-capable icing tunnel. Probes qualified to Class 2 of this standard shall be identified as either Class 2a or Class 2b.</p> <hr/> <p>Replace the second "NOTE" with the following:</p> <p>NOTE: This specification, when used in conjunction with AS8006A, provides a comprehensive design and test standard for the devices that fall within the scope of this document.</p> <hr/> <p>Page 1, Disregard the following: "<i>Note: this document is technically equivalent to EUROCAE ED-225, dated TBD.</i>" This TSO is based on SAE AS5562 as modified by this appendix.</p>
Section 2	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 2, Replace subsection 2.1, with the following text:</p> <p>2.1 Applicable Documents</p>

	<p>The following publications form a part of this document to the extent specified herein. The applicable issue of <i>cited</i> publications shall be the issue in effect on the date of the publication of this document, unless otherwise specified. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document; however, supersedes applicable laws and regulations unless a specific <i>deviation or exemption</i> has been obtained.</p> <hr/> <p>Page 3, Add subsection 2.3</p> <p>2.3 General Definitions</p> <p>SHALL: The word “shall” is used in this document to express an essential requirement where compliance is mandatory.</p> <p>MUST: The word “must” is used in this document to express an essential requirement where compliance is mandatory.</p>
Section 3	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 4, replace the fifth paragraph subsection 3.1.1 with the following text to modify an incorrect reference to 14 CFR Part 25, Appendix D:</p> <p>Mixed Phase: Consists of the combination of SLW and IC icing conditions. The liquid phase is taken from the application of 14 CFR Part 25 Appendix C intermittent maximum icing conditions at the standard 2.6 nautical mile horizontal extent. The solid phase is derived by applying a distance scale factor for 2.6 nautical miles to the theoretical adiabatic maximum total water content as defined in 14 CFR Part 33 Appendix D. This is done over an altitude range of sea level to that consistent with a static air temperature above -40 °C, as -40 °C constitutes the theoretical minimum temperature for the existence of supercooled liquid water. The temperature range considered shall be -10 to -40 °C. The MVD and MMD shall be consistent with those used for SLW and IC icing conditions.</p> <p>Page 5, replace the first paragraph subsection 3.2 with the following text:</p> <p>This standard defines five aircraft classes with the intent to specify the minimum icing test conditions appropriate to the flight envelope addressed by each class. In this fashion, test requirements can be better matched to the particular application. As with any minimum performance standard, application specific requirements may exceed those defined in this specification; the user of this standard is cautioned to closely examine application specific requirements to verify the appropriateness of the test conditions presented in this standard. If necessary, the test conditions may be modified. However, parts identified as having met this standard must meet or exceed the requirements specified in this document. <i>Modifications to the test conditions may only be applied if an equivalent level of safety is documented,</i></p>

	<p><i>justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p> <hr/> <p>Page 5, replace subsection 3.3 with the following text:</p> <p>3.3 Test Point Scaling</p> <p>When a particular freestream (reference) test condition cannot be achieved due to a test facility limitation, the following scaling methods shall be used to arrive at an achievable test condition. Other scaling methods may be acceptable so long as they are shown to be conservative for the respective test condition. <i>Alternate scaling methods may only be applied if an equivalent level of safety is documented, justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p> <hr/> <p>Page 5, replace the NOTE in subsection 3.3.1 with the following text:</p> <p>NOTE: Ice crystal scaling methods continue to evolve. Suitable methods for scaling altitude may be developed in the future. These methods must be thoroughly validated. <i>Alternate scaling methods may only be applied if an equivalent level of safety is documented, justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p>
Section 4	<p>Apply all subsections unless disregarded or modified below:</p> <hr/> <p>Page 7, Paragraph 4.5 add the following note:</p> <p><i>NOTE: The probe test voltage reported to the installer shall not include any voltage adjustments made per paragraph 4.9 to simulate worse case heater performance.</i></p>
Table 5 – Ice crystal test conditions	<p>Page 15, Replace Note 3. With the following:</p> <p>3. A different MMD value may be used if it can be shown that the change in probe collection efficiency is less than 2%. If a value outside the specified range is used, <i>an equivalent level of safety must be documented, justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p>
Table 6 – Rain test conditions	<p>Page 15, Replace Note 2. With the following:</p> <p>2. A lower MVD value may be used if it can be shown that the change in probe collection efficiency is less than 2%. If a value outside the specified range is used, <i>an equivalent level of safety must be documented, justified, and approved by the FAA as a deviation in accordance with 14CFR 21.618.</i></p>